

THE IMPACTS OF ENVIRONMENTALLY SOUND LAND USE METHODS ON THE HUMUS CONTENT OF THE SOIL

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Abstracts: Soil is one of the most important natural resources and its main feature is its fertility. Soil fertility depends on the quantity and quality of humus. Humus has a very important role in the formation of soil structure, the nutrient, water and heat management and the buffering capacity of the soil. The organic matter content of soils depends on the input of organic matter, the rate of its degradation and climate conditions. The mineralisation of organic substances in soil could be influenced by agro-technical and different nutrient supply methods. The long-term preservation of soil fertility is represented by the 85 years old Westsik's long-term crop rotation experiment. In this experiment, we examined the effect of different fertilisation methods (straw manure, farmyard manure, artificial fertiliser and primary and secondary lupin green manure) on the humus content of soil and the yield of potato and rye. The humus content of the soil is below 1%, but the different nutrient supplying methods have different impacts on humus content. Our results show that the highest humus content of the soil was observed in the treatment with a large dose of straw manure + artificial fertiliser. The highest yields of rye and potato were obtained in the case of primary and secondary lupin green manure and farmyard manure + artificial fertiliser treatments.

Keywords: humus, organic matter, green manure, straw manure, farmyard manure

Introduction

The fundamental element of sustainable land use is the nutrient supply system which is adjusted to the crop needs and the production site conditions. In this system, significant amount of organic manure is used (Várallyay, 1997). Soil fertility is greatly affected by the humus content of the soil which can be significantly modified by the used farming method and land use. Based on the evaluation of long-term experiment data, it was concluded that the change of humus content – mostly decrease – is a result of physical impacts and cultivation (Németh, 1996). During cultivation, the increase of the organic carbon and humus content of the soil should be addressed (Kismányoky, 2009). Hoffmann et al. (2010) observed better efficiency of active ingredient-equivalent fertilisers from the aspect of yield during the examination of organic manure and artificial fertilisers on brown forest soil in a long-term experiment. The aim of our examinations is to determine the impact of nutrient supply and production site endowments on the humus content of the soil in a long-term experiment established under unfavourable edaphic conditions. It was also an objective to determine the correlation between the humus content of the soil and the potato and rye yields.

Materials and methods

The examinations were carried out in the long-term Westsik's crop rotation experiment established in 1929 at the DE AGTC KIT Nyíregyháza Research Institute's site. The soil of the experiment site has low plasticity ($K_A=28$), acidic pH and weak water retaining capacity. The experiment demonstrates different methods of nutrient replenishment in 15 crop rotation models. 14 of the crop rotations are three-year-cycle models and one is a four-year-cycle model. Neither organic manure, nor artificial

fertiliser is applied in the control (I) crop rotation and there is one year of ley-farming. In crop rotation II, lupin as the main crop is used as green manure, while seed lupin is produced as the main crop in crop rotation III. In crop rotations IV, V, VI and VII, we use straw manure fermented in different ways. In crop rotation IV, raw straw is used as manure (3.5 t ha^{-1}); straw manure fermented with nitrogen fertiliser is used in crop rotation V (11.3 t ha^{-1}), while there is no fertiliser in crop rotations VI and VII, we only apply straw manure fermented with water (26.1 t ha^{-1}). In crop rotation VIII, lupin is present twice in the crop rotation cycle (seed production and green manure), while it is sown for green manure purposes in crop rotation IX. Farmyard manure is applied in crop rotations X and XI (26.1 t ha^{-1}). In crop rotation XII, lupin green manure is used after autumn sown forage production. Of the secondarily sown green manure crop rotations, the green manure is incorporated into the soil in the autumn in crop rotation XIII and in the spring in crop rotation XIV. In the area of the experiment, there is a hill-line typical of the Nyírség region; therefore, we had the opportunity to examine the impacts of the treatments in addition to the different production site endowments (exposure, elevation above sea level). In the experimental plots, we designated sample areas in accordance with low-lying and hilly areas. In the sample areas, we took soil samples in three replications in order to determine the humus content and we took crop samples to perform yield estimation. The humus content was determined on the basis of the MSZ 21470:1983. 2 analytical method. The statistical evaluation was carried out with one-way analysis of variance and linear correlation calculation.

Results and discussion

Our examination results are shown in Table 1. Low humus content was measured in all crop rotations in the samples of the experiment area, but there is significant difference between the respective values of high-lying (104.64-109.68 m above sea level) and low-lying areas (103.39-105.09 m above sea level). Even within one crop rotation, lower humus content was observed in high-lying parts (0.5%), and higher values were obtained in low-lying parts (0.7% on average). Comparing the crop rotations to each other, it can be observed in low-lying areas that there is much smaller difference in the impact different organic manure application methods have on the humus content than in the sample plots designated in high-lying areas. In low-lying areas, there is no significant difference between the impacts of farmyard manure and the green manure originating from primarily or secondarily sown crops on humus content. The extent of humus content increase observed in the case of straw manure crop rotations is not significant. The lowest humus content (0.31%) was obtained in the high-lying parts of the non-fertilised crop rotation (I), while the highest humus content (0.91%) was measured in the soil which was treated with fermented straw manure (V) in a low-lying area. The highest yields can be obtained with using farmyard manure under the conditions of the Westsik long-term experiment (Table 1). In addition to organic manure, papilionaceous plants also have significant role in maintaining the fertility of the unfavourable sandy soils. In the crop rotation where lupin is sown both primarily and temporarily, the obtained yields were similar to farmyard manure application.

Table 1. Crop rotation parameters of the Westsik long-term experiment

(Nyíregyháza, 2012)

Crop rotations	Sampling point	Elevation above sea level (m)	Humus (%)	Potato yield (t ha ⁻¹)	Rye yield (t ha ⁻¹)
I	low-lying	104,04	0,72	18,52	2,20
II		104,34	0,71	15,81	2,84
III		104,36	0,74	20,93	2,63
IV		104,32	0,82	21,86	2,65
V		103,85	0,91	18,59	2,60
VI		103,39	0,77	24,93	2,73
VII		103,61	0,61	14,42	0,77
VIII		104,14	0,63	28,36	2,48
IX		105,09	0,46	17,92	1,94
X		104,97	0,62	27,00	2,12
XI		104,14	0,74	35,48	3,43
XII		104,01	0,69	14,56	2,17
XIII		104,00	0,74	13,07	2,49
XIV		104,50	0,73	16,11	2,22
XV		104,38	0,64	12,26	0,92
I	high-lying	107,16	0,31	7,42	0,41
II		109,50	0,38	10,83	0,83
III		109,68	0,33	12,97	0,61
IV		108,34	0,52	15,75	1,73
V		107,27	0,61	26,87	2,12
VI		105,12	0,77	21,84	1,88
VII		104,64	0,77	11,93	1,36
VIII		104,79	0,72	22,35	2,89
IX		106,62	0,38	10,19	0,99
X		107,63	0,62	23,24	2,27
XI		107,41	0,58	28,11	1,25
XII		108,19	0,35	11,32	0,56
XIII		108,19	0,45	13,74	1,13
XIV		108,51	0,44	17,09	1,15
XV		108,28	0,45	10,68	0,37

The impact of crop rotations on humus content was shown to be significant in both sample areas. The difference between the extreme values of the high- and low-lying areas is nearly identical (0.45% and 0.46%) in terms of humus content, but the impact expressed in relative values observed in high-lying sample areas is larger. The humus content in the soil of the straw manure (IV, V, VI, VII) and the farmyard manure (X, XI) crop rotations is higher than in the primarily sown green manure (II) and the secondarily sown green manure (XII, XIII, XIV, XV) crop rotations or in the crop rotations where lupin is sown as the main crop, but there is no organic manure application (III, IX). The lowest humus content was obtained in the case of the non-fertilised crop rotation (I). There was a close negative correlation ($r = -0.809$) between the elevation above sea level and the humus content. Even when the different organic manure methods are used in the experiment, the humus content of the soil is lower in high-lying areas than in low-lying areas (Table 2). The impact of the elevation above sea level is shown by the fact that the low humus content measured in the high-lying

crop rotation IX belongs to the highest elevation above sea level among all crop rotations.

Table 2. Coefficient of correlation of the linear correlation (r value)

Pearson's correlation	Humus (%)
Elevation above sea level (m)	-0,809 **
n	30

Level of significance **=1%

There was medium positive correlation ($r=0.486$) between humus content and the potato and rye yields in the crop rotation and the correlation was strong positive ($r=0.785$) in the case of rye (Table 3).

Table 3. Coefficients of correlation of the linear correlation (r values)

Pearson's correlation	Potato yield (t ha ⁻¹)	Rye yield (t ha ⁻¹)
Humus (%)	0,486 **	0,785 **
n	30	30

The different fertilisation methods can affect humus content only slightly without any strong statistical correlations, but the applied organic manure still had a large yield increasing effect.

Conclusions

Production site endowments have a determinant role in humus content, i.e., soil fertility, but it is possible to influence them with production technology and organic manure application. Under the peculiar terrain conditions of the Westsik long-term experiment, the elevation above sea level has a significant impact on the humus content even within a certain crop rotation phase. In the case of weak production site endowments, it is possible to increase the humus content of the soil with farmyard manure more than with green manure application, but the impact of various treatments on humus content is stronger in high-lying areas.

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